Biological Assessment and Channel Evaluation Report

Middle Fork Grand River
Worth and Gentry Counties,
Missouri

2004-2005

Prepared for:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Branch

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1.0 Introduction

The Middle Fork Grand River flows southerly into northwest Missouri from Iowa (Figure 1). In Missouri, the stream travels for approximately 25 miles to its confluence with the West Fork Grand River, where it becomes the Grand River (Figure 2). The Middle Fork Grand River has a 226-sq. mi. drainage area with a 36-mile long channel (Funk 1968).

The Middle Fork Grand River is considered a class “P” stream, which maintains permanent flow even in periods of drought. The Middle Fork Grand River has designated uses (MDNR 2005c) for irrigation (**IRR**); livestock and wildlife watering (**LWW**); protection of warm water aquatic life and human health-fish consumption (**AQL**); whole body contact (**WBC**), category A; and secondary contact recreation (**SCR**).

1.1 Justification

The Middle Fork Grand River, Worth and Gentry Counties is on the Missouri Department of Natural Resources 2002 list of impaired waters under section 303(d) of the Federal Clean Water Act. Middle Fork Grand River is included on the 303(d) list for excessive sediment problems from agriculture non-point sources (**Ag.NPS**). The section 303(d) listed reach has a “Medium” priority for evaluation.

The Middle Fork Grand River study was conducted at the request of the Missouri Department of Natural Resources (**MDNR**), Water Protection Program (**WPP**), Water Pollution Control Branch (**WPCB**).

A biological assessment was conducted on Middle Fork Grand River, Worth and Gentry Counties in the fall of 2004 and spring of 2005. A stream habitat assessment was conducted and channel morphology was measured in fall 2004. The Aquatic Bioassessment Unit of the Environmental Services Program (**ESP**), Water Quality Monitoring Section (WQMS) coordinated this study. Kenneth B. Lister, David Michaelson, and staff of the Water Quality Monitoring Section conducted the study.

1.2 Purpose

Determine if Middle Fork Grand River is biologically impaired in the 303(d) listed study reach.

1.3 Objectives

1) Assess the macroinvertebrate community integrity and water quality in Middle Fork Grand River.

2) Assess the stream habitat quality of Middle Fork Grand River.

3) Measure and compare stream morphology and channel modifications.

1.4 Tasks

1) Conduct a stream habitat assessment for Middle Fork Grand River and East Fork Grand River.

2) Conduct a biological assessment, including macroinvertebrate and water physicochemical collection and analyses, for Middle Fork Grand River.

3) Compare biological assessment results to wadeable/perennial stream biological criteria and metrics between stations.

4) Compare physicochemical water quality from upstream to downstream as well as with Water Quality Standards (MDNR 2000).

5) Record and analyze channel measurements at Middle Fork Grand River and compare with East Fork Grand River, an unchannelized stream.

1.5 Null Hypotheses

Stream habitat assessment will be similar between test stations and the stream habitat control station.

Middle Fork Grand River, Worth and Gentry Counties will be similar to wadeable/perennial stream biological criteria, as well as between all stations.

Physicochemical water quality will be similar at all stations and acceptable with Missouri Water Quality Standards (MDNR 2005c).

Channel measurements will be similar between the test stations and control station.

2.0 Methods

The study area, station descriptions, Ecological Drainage Units (**EDUs**), and land use are identified. The study timing is outlined. Methods are included for stream habitat assessments, biological assessments, and physicochemical water quality collection.

2.1 Study Area and Station Descriptions

The study area included approximately 25 miles on Middle Fork Grand River in Worth and Gentry Counties (Table 1; Figure 1). Four stations were allocated for this study and were positioned approximately five miles apart (Table 1; Figure 2). Station #4 was located upstream of Missouri Highway 46, approximately one mile east of Grant, Missouri. Station #3 was located upstream of the Highway YY bridge, north of Worth, Missouri. Station #2 was located downstream of U.S. Highway 169, 0.5 miles east of Gentry, Missouri. Station #1 was located upstream of U.S. Highway 136 approximately five miles west of Albany, Missouri. A single station was allocated for stream habitat assessment and channel measurement controls on East Fork Grand River, Worth County. This station was approximately five miles east of Grant, Missouri and downstream of Missouri Highway 46.

Table 1
Location and Descriptive Information for Middle Fork Grand River and East Fork Grand River, Worth and Gentry Counties, 2004-2005

Stream-Station Number	Location-Section, Township, Range	Description	County
Middle Fork Grand River #4	SE ¼ sec. 27, T. 66 N., R. 31 W.	Upstream bridge MO Hwy. 46	Worth
Middle Fork Grand River #3	SE ¼ sec. 24, T. 65 N., R. 32 W.	Upstream bridge County Road YY	Worth
Middle Fork Grand River #2	SE ¼ sec. 20, T. 64 N., R. 31 W.	Downstream bridge U.S. Hwy. 169	Gentry
Middle Fork Grand River #1	SW ¼ sec. 21, T. 63 N., R. 31 W.	Upstream bridge U.S. Hwy. 136	Gentry
East Fork Grand River #1 (SHAPP and Channel Measure)	N ½ sec. 32, T. 66 N., R. 30 W.	Downstream bridge MO Hwy. 46	Worth

2.1.1 Ecological Drainage Unit

The Middle Fork Grand River is within the Plains/Grand/Chariton EDU (Figure 1). Ecological Drainage Units are delineated drainage units in which similar size streams are expected to contain similar aquatic communities and stream habitat conditions. Comparisons of biological and physicochemical results between test streams and similar size reference streams within the same EDU should then be appropriate.

2.1.2 Land Use Description

Land cover of the Plains/Grand/Chariton EDU was compared to the 14-digit Hydrological Unit (**HUC-14**; Table 2) land cover of each station on Middle Fork Grand River and the East Fork Grand River. Percent land cover data were derived from Thematic Mapper (TM) satellite data collected between 2000 and 2004 and interpreted by the Missouri Resource Assessment Partnership (**MoRAP**).

The dominant land cover in the immediate watershed of all stations was grassland, followed by crops (Table 2). All stations were relatively similar in percentages, with grassland in the range of 54-64 percent and crops in the range of 23 to 35 percent. The EDU was similar to the individual HUCs with 53 percent grassland and 30.3 percent crops. All other categories were similar between stations and the EDU. Similarities suggest that land use should not effect interpretation of the findings.

2.2 Study Timing

Sampling was conducted in the fall of 2004 and the spring of 2005. Stream habitat assessments were conducted and channel measurements recorded at Middle Fork stations on September 7 and 8, 2004. Fall macroinvertebrate and physicochemical water sampling was conducted on September 14 and 15, 2004. East Fork Grand River channel measurements were recorded on October 5, 2004. Spring sampling included macroinvertebrate collections and physicochemical samples and measurements on March 23, 2005.

Table 2
Percent Land Cover in the Middle Fork Grand River and
East Fork Grand River Stations and Plains/Grand/Chariton EDU

Stations	HUC-14	Urban	Crops	Grassland	Forest	Swamp
Middle Fork Grand River #4	10280101050004	0.1	24.3	64.1	11.2	0
Middle Fork Grand River #3	10280101050005	0	31.1	57.1	11.4	0
Middle Fork Grand River #2	10280101050007	0	32.8	54.2	12.7	0
Middle Fork Grand River #1	10280101050008	0	34.7	55.8	9.2	0
East Fork Grand River #1	10280101060008	0	23.4	61.4	14.9	0
Plains/Grand/ Chariton EDU	--	0.2	30.3	53.0	15.2	0.1

2.3 Stream Habitat Assessment Project Procedure

The standardized Stream Habitat Assessment Project Procedure (**SHAPP**) was followed as described for Glide/Pool prevalent streams (MDNR 2003d). Stream habitat assessment scores were compared between test stations from upstream to downstream and between the scores at test and control stations. According to the SHAPP, the quality of an aquatic community is based on the stream's ability to support the aquatic community. If SHAPP scores at test stations are $\geq$75% of the mean control scores, the stream habitat at the test station is considered to be comparable to the reference (control) stream. East Fork Grand River, Worth County was used as the control (Figure 2). Stream habitat assessment scores were compared from upstream to downstream and with the SHAPP control.

2.4 Biological Assessment

Sampling was conducted as described in the MDNR Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP,** MDNR 2003c). Biological assessments consisted of macroinvertebrate community and physicochemical water collection and analyses. Macroinvertebrates and physicochemical water variables were analyzed at four stations in Middle Fork Grand River, Worth and Gentry Counties.

Figure 1: Middle Fork Grand River in the Plains/Grand/Chariton EDU, 2004-2005.

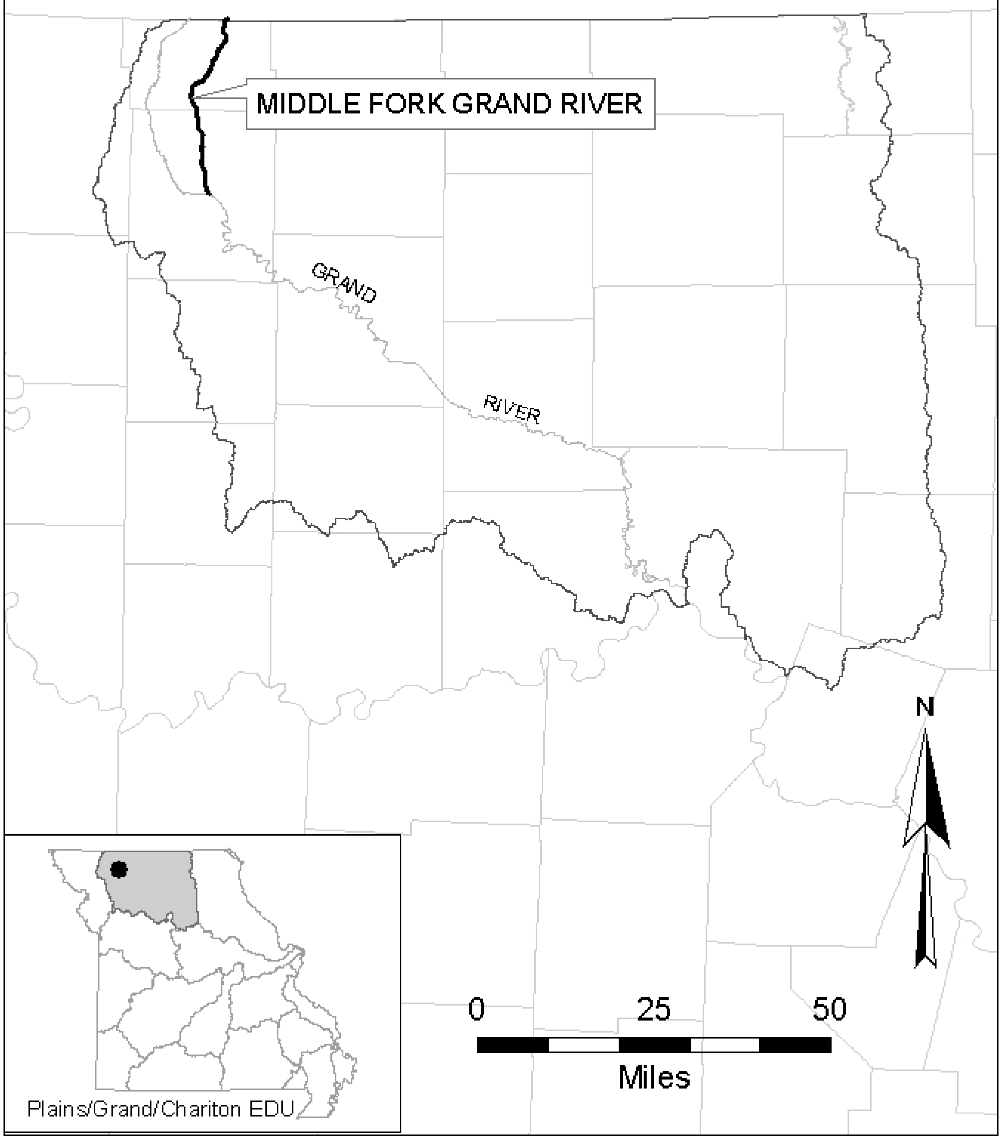
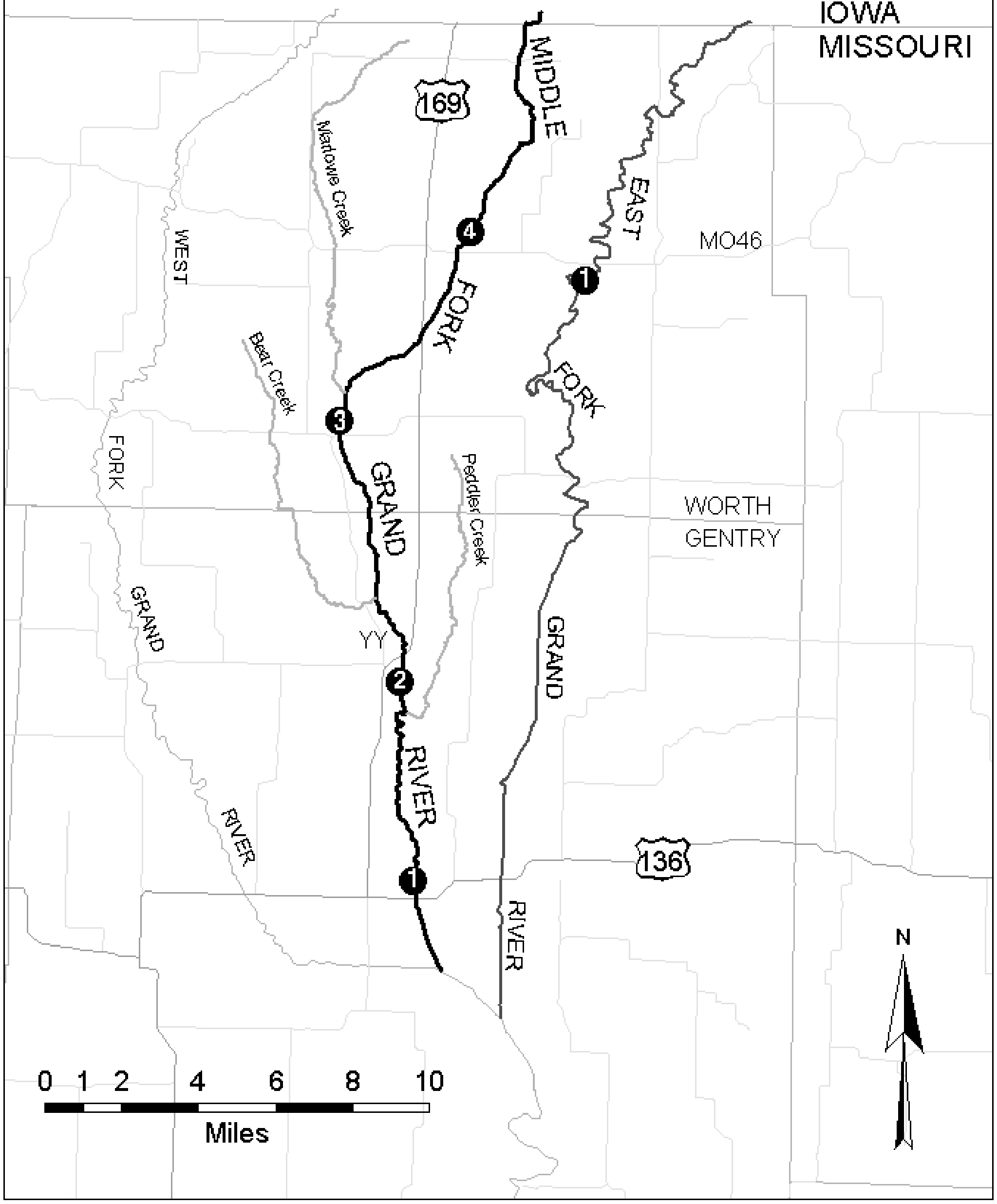


Figure 2: Middle Fork Grand River and East Fork Grand River stations in Worth and Gentry Counties, 2004-2005.



2.4.1 Macroinvertebrate Sampling

Macroinvertebrates were sampled from multiple habitats as described in the SMSBPP. Middle Fork Grand River is considered a glide/pool dominant stream and habitats were sampled accordingly. Non-flowing water over depositional substrate (**NF**), large woody debris (**SG**), and rootmat (**RM**) habitats were sampled.

Macroinvertebrate community data were analyzed using three strategies. Stream Condition Index (**SCI**) scores, individual biological criteria metrics, and dominant macroinvertebrate families (**DMF**) were examined and compared from upstream to downstream.

A Stream Condition Index is a qualitative rank measurement of a stream's aquatic biological integrity (Rabeni et al. 1997). The SCI was further refined for reference streams within each EDU in Biological Criteria for Perennial/Wadeable Streams (**BIOREF,** MDNR 2002).

A station's SCI score is a compilation of rank scores that were assigned to individual biological criteria metrics as a measure of biological integrity. Four primary biological criteria metrics were used to calculate the SCIs per station: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). Metric scores were compared to the BIOREF scoring range (SCI Scoring Table, Tables 4 and 5) and rank scores (5, 3, 1) were assigned to each metric (Tables 4 and 5). For each station, rank scores were compiled from all metrics and the SCI was completed. The SCI scores are interpreted as follows: 20-16 = full biological support; 14-10 = partial biological support; and 8-4 = non-support of the biological community. SCI scores were compared between stations and grouped by season.

Secondly, the individual biological criteria metrics for each station were compared to the BIOREF scoring range to identify the level of integrity for each individual metric. Variations in the metrics may help identify how a community is affected and the potential source of impairment.

The third biological analysis was an evaluation of the "dominant macroinvertebrate families" (**DMF**) per station. The DMFs are listed as a percentage of the total number of individuals in the sample. Dominance by certain families may also help identify the type and source of impairment. A taxa list reported by season and station is attached as Appendix A.

2.4.2 Physicochemical Water Sampling

Physicochemical water samples were handled according to the appropriate MDNR, ESP Standard Operating Procedure (**SOP**) and/or Project Procedure (**PP**) for sampling and analyzing physicochemical water samples. Results for physicochemical water variables were examined by season and station.

Fall 2004 and spring 2005 physicochemical water parameters consisted of field measurements and grab samples that were returned to the ESP environmental laboratory. Water was sampled according to the SOP MDNR-FSS-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2003b). All samples were kept on ice during transport to ESP.

Temperature (C^o), pH, conductivity (uS), dissolved oxygen (mg/L), and discharge (cubic feet per second-**cfs**) were measured in the field. The ESP, Chemical Analysis Section (**CAS**) in Jefferson City, Missouri conducted analyses for ammonia-nitrogen (mg/L), nitrate+nitrite-nitrogen (mg/L), Total Kjeldahl Nitrogen (**TKN**; mg/L), chloride (mg/L), and total phosphorus (mg/L). Turbidity (NTU) was measured and recorded in the WQMS biology laboratory.

Physicochemical water parameters were compared between stations from upstream to downstream as well as with acceptable limits in Missouri's Water Quality Standards (**WQS**, MDNR 2005c). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and its beneficial-use designation (MDNR 2005c). Middle Fork Grand River is a class "P" stream, with designated uses for IRR, LWW, AQL, WBC, and SCR. Furthermore, acceptable limits for some parameters may be dependent on the rate of exposure. These exposure or toxicity limits are based on the lethality of a toxicant given long (chronic toxicity, **c**) or short-term exposure (acute toxicity, **a**).

2.4.3 Discharge

Stream flow was measured using a Marsh-McBirney Flowmate™ flow meter at each station. Velocity and depth measurements were recorded at each station according to SOP MDNR-WQMS-113 Flow Measurement in Open Channels (MDNR 2003a).

2.5 Channel Measurements

Channelized streams may be wider and shallower than non-channelized streams (MDNR 2005a). Basic channel morphology was measured to illustrate the size and shape of the stream as well as potentially identify channelization.

Channel measurements included wetted width, depth, channel width, and sinuosity. Wetted width included the width that contained water and was measured from edge to edge of the water filled channel. The depth of the stream was measured within the wetted width and was taken at three depth measurement points which correspond to ¼, ½, and ¾ wetted width distance. The standard deviation of depth (S.D. of Depth) was calculated to illustrate variability of depth. Channel width included the width of the normal high water channel between the top of the lower banks as described in MDNR 2003d. A wetted width to channel width ratio illustrated the normal low flow width to high flow width at each station. Channel measurements were recorded (in feet) at ten transects within each station. Stream length is the length of each station, which is defined as approximately 20 times the average channel width (MDNR 2003c).

Sinuosity is a ratio of the actual distance per straight-line (aerial) distance between two points that are approximately two miles apart. The sampling station was located near the center of the two-mile segment.

The data were examined for similarities between stations as well as with the control station. Further data analysis included statistical comparisons of channel measurements using SigmaStat, Version 2.0 (1997).

2.6 Quality Control

Quality control was utilized in accordance with MDNR SOPs and Project Procedures.

3.0 Results and Analyses

Results are grouped by stream habitat assessment, biological assessment, and channel measurements. Trends and exceptional results are highlighted.

3.1 Stream Habitat Assessment

Stream habitat assessment scores (Table 3) decreased slightly from upstream to downstream with an average of 90.5. The test stations were comparable to the SHAPP control score.

Table 3
Stream Habitat Assessment Scores for Middle Fork Grand River (MFG) and East Fork Grand River (EFG), Fall 2004

	MFG #4	MFG #3	MFG #2	MFG #1	EFG #1
SHAPP Scores	106	95	83	78	95
Percent of SHAPP Control Score (East Fork Grand River)	112	100	87	82	--

3.2 Biological Assessment

Biological assessments consist of macroinvertebrate community analyses and physicochemical water quality analyses. Results are compared between stations from upstream to downstream.

3.2.1 Macroinvertebrate Community Analyses

The macroinvertebrate community is examined in this section. Stream condition index (SCI) scores, individual metric scores, and dominant macroinvertebrate families are examined from upstream to downstream.

3.2.1.1 Stream Condition Index Scores and Individual Biological Criteria Metrics

All stations were placed in the “full biological support category” in the fall (Table 4). Furthermore, all stations received SCI scores of 20. The BIOREF “optimum” scores were exceeded by all individual metrics that derived the SCI.

Table 4
Fall 2004 Biological Criteria (n=15) Metric Scores and Stream Condition Index (SCI) Scores for Middle Fork Grand River (MFG) Stations, Worth and Gentry Counties

Stream Station Number	Sample No.	TR	EPTT	BI	SDI	SCI	Biological Support Category
MFG #4	0418721	65	14	7.02	2.92	20	Full
MFG #3	0418720	76	16	6.72	3.19	20	Full
MFG #2	0418719	74	17	6.49	3.24	20	Full
MFG #1	0418718	70	18	6.66	3.23	20	Full
BIOREF Score=5	--	>51	>9	<7.20	>2.68	20-16	Full
BIOREF Score=3	--	51-26	9-4	7.20-8.60	2.68-1.34	14-10	Partial
BIOREF Score=1	--	<26	<4	>8.60	<1.34	8-4	Non

(SCI Scoring Table in light gray)

The spring SCI (Table 5) indicates most stations were placed in the full biological support category, with the exception of #2. Station #2 was partially supporting of the macroinvertebrate community with an SCI score of 14. All stations were below the fall scores.

The EPTT and BI scores, each of which received a score of 3, affected the SCI score at station #4. Only the SDI score lowered station #3. Three metrics contributed to the lower scores at station #2 (Table 5). The TR, EPTT, and SDI were each in the BIOREF scoring range of 3. The BI at #2 was within the optimum BIOREF scoring range and scored 5 points. The SCI at station #1 was affected by the TR and SDI, which lowered each BIOREF score to 3.

Table 5
Spring 2005 Biological Criteria (n=21) Metric Scores and Stream Condition Index (SCI) Scores for Middle Fork Grand River (MFG) Stations, Worth and Gentry Counties

Stream Station Number	Sample No.	TR	EPTT	BI	SDI	SCI	Biological Support Category
MFG #4	0503013	56	**7**	**7.25**	2.66	16	Full
MFG #3	0503012	60	10	7.04	**2.46**	18	Full
MFG #2	0503011	**46**	**8**	6.84	**2.47**	**14**	**Partial**
MFG #1	0503010	**49**	10	7.20	**2.45**	16	Full
BIOREF Score=5	--	>51	>8	<7.24	>2.53	20-16	Full
BIOREF Score=3	--	51-26	8-4	7.24-8.61	2.53-1.26	14-10	Partial
BIOREF Score=1	--	<26	<4	>8.61	<1.26	8-4	Non

((SCI Scoring Table in light gray)

Individual metrics showed no distinct pattern from upstream to downstream in the spring (Table 5). The TR was consistent at stations #4 and #3, while stations #2 and #1 were consistent but much lower than upstream. The EPTT fluctuated from upstream to

downstream with no obvious pattern. The BI was slightly higher at station #4 than the remaining stations. The SDI at #4 was within the optimum BIOREF range.

3.2.1.2 Dominant Macroinvertebrate Families

Three families were consistently among the most dominant macroinvertebrate families sampled in the fall (Table 6). Chironomidae dominated all stations. Caenidae was the second most dominant family. Hyalellidae was generally dominant thereafter.

Table 6
Dominant Macroinvertebrate Families (DMF) as a Percentage of the
Total Number of Individuals per Station, Fall 2004

Stream/Station	MFG #4	MFG #3	MFG #2	MFG #1
Sample Number	0418721	0418720	0418719	0418718
Chironomidae	**43.2**	**57.6**	**49.8**	**56.1**
Caenidae	**24.6**	**14.7**	**15.4**	**14.5**
Hyalellidae	**13.1**	**6.7**	**--**	**5.4**
Leptoceridae	3.9	7.4	9.0	6.5
Baetidae	3.1	3.3	6.2	4.7
Coenagrionidae	2.7	1.3	2.0	1.2
Ceratopogonidae	1.8	--	--	--
Sphaeriidae	0.8	--	--	--
Ephemeridae	--	2.1	--	1.3
Dryopidae	--	1.0	1.5	--
Hydropsychidae	--	--	6.1	1.7
Leptohyphidae	--	--	2.5	--

Table 7
Dominant Macroinvertebrate Families (DMF) as a Percentage of the
Total Number of Individuals per Station, Spring 2005

Stream/Station	MFG #4	MFG #3	MFG #2	MFG #1
Sample Number	0503013	0503012	0503011	0503010
Chironomidae	**77.6**	**84.4**	**82.9**	**91.9**
Caenidae	**14.5**	**7.3**	**7.6**	**2.9**
Hyalellidae	**2.3**	**2.3**	**1.1**	**1.6**
Ceratopogonidae	1.7	--	--	0.4
Coenagrionidae	0.9	--	--	--
Dytiscidae	0.7	--	--	--
Hydropsychidae	0.3	--	--	0.4
Leptoceridae	0.1	0.3	0.6	--
Simuliidae	--	1.0	3.9	1.0
Baetidae	--	0.5	0.7	--
Corixidae	--	--	0.5	--
Heptageniidae	--	--	0.4	0.3
Ephemeridae	--	0.3	--	0.2
Tubificidae	--	1.6	--	--

Three families were consistently ranked among the dominant families at all stations in the spring (Table 7). Chironomidae dominated all stations. The second most dominant family was Caenidae. Hyalellidae was the third most dominant family, with the exception of station #2. A taxa list identified a large number of dipterans, a decrease in ephemeropterans, and more precisely illustrates the dominance by these families (Appendix A).

3.2.2 Physicochemical Water Variables

Several physicochemical water parameters exhibited interesting trends during the fall 2004 season (Table 8). Conductivity was slightly elevated at all stations. Turbidity was higher at station #4 than the downstream stations. Chloride was detected and decreased slightly from upstream to downstream. The TKN was detected at low levels in all stations. Ammonia-N was not detected at any station. Total phosphorus was detected in very low levels at all test stations. No measure or concentration exceeded Missouri WQSs (MDNR 2005c).

Several physicochemical water parameters also exhibited interesting trends in the spring 2005 season (Table 9). Conductivity was similar at all stations. TKN was detected at low concentrations in all stations. Ammonia was not detected (<0.03) at any station. Chloride was detected and the concentration decreased from upstream to downstream. Total phosphorus was detected at very low levels in all stations. No measure or concentration exceeded Missouri WQSs (MDNR 2005c).

Table 8
Physicochemical Water Variables per Station,
Middle Fork Grand River (MFG), Worth and Gentry Counties, Fall 2004

Station Variable	MFG #4	MFG #3	MFG #2	MFG #1
Sample Number	0411656	0411655	0411654	0411653
pH (Units)	7.60	8.30	7.70	7.70
Temperature (C^0)	21.0	28.5	25.5	24.5
Conductivity (uS)	534	549	519	485
Dissolved O_2	6.32	7.90	6.99	7.70
Discharge (cfs)	3.27	3.32	5.20	8.29
Turbidity (NTUs)	18.1	5.14	5.19	4.40
Nitrate+Nitrite-N	0.03	<0.01	<0.01	0.02
TKN	0.53	0.57	0.41	0.52
Ammonia-N	<0.03	<0.03	<0.03	<0.03
Chloride	17.2	18.0	14.8	13.0
Total Phosphorus	0.10	0.09	0.08	0.07

(Units mg/L unless otherwise noted)

Table 9
Physicochemical Water Variables per Station,
Middle Fork Grand River (MFG), Worth and Gentry Counties, Spring 2005

Station Variable/ Date	MFG #4	MFG #3	MFG #2	MFG #1
Sample Number	0502946	0502945	0502944	0502943
pH (Units)	8.20	8.20	8.10	8.20
Temperature (C^0)	9.0	7.0	6.0	5.50
Conductivity (uS)	526	558	532	523
Dissolved O_2	13.5	13.5	13.4	13.4
Discharge (cfs)	9.80	16.3	19.7	19.3
Turbidity (NTUs)	5.81	8.14	6.57	3.86
Nitrate+Nitrite-N	<0.01	0.01	<0.01	<0.01
TKN	0.25	0.30	0.24	0.20
Ammonia-N	<0.03	<0.03	<0.03	<0.03
Chloride	22.0	20.0	16.8	16.0
Total Phosphorus	0.07	0.07	0.05	0.06

(Units mg/L unless otherwise noted)

3.3 Channel Measurements

Channel measurements were recorded at test stations on Middle Fork Grand River and compared to the SHAPP control at East Fork Grand River (Table 10). Several channel measurements at the Middle Fork Grand River appeared to illustrate a difference from the control station (Table 10; Appendix B). The Middle Fork Grand River was less sinuous than the control station. The channel width was significantly greater than the wetted width in both test ($p<0.001$; $t=13.248$, 78 d.f.) and control ($p<0.005$; $T=142.5$, $n=10$) streams. The channel width of the test stream was significantly wider (<0.001; $T=86.0$, $n=40$) than the channel width of the control stream ($n=10$; Appendix B). Finally, most test stations were slightly deeper and depth was slightly more variable (S.D. of Depth) at most test stations compared to the control. Wetted width measurements in the test stream were similar ($p=0.303$; $T=298.0$, $n=40$) to the control stream measurements ($n=10$).

4.0 Discussion

The discussion includes the stream habitat assessment, biological assessment, and channel measurements. Notable results or trends are highlighted from upstream to downstream.

Table 10
Channel Measurements for Middle Fork Grand River (MFG) Stations
and East Fork Grand River (EFG)

	CW	WW	CW/WW	DEPTH	MAX DEPTH	S.D. OF DEPTH	SINUOSITY (actual/straight-line)	STREAM LENGTH
MFG4	61.8	27.5	2.25	0.63	1.75	0.45	1.06	3279
MFG3	67.5	42.9	1.57	0.91	1.63	0.37	1.07	3171
MFG2	83.3	35.9	2.32	0.90	3.50	0.76	1.10	3245
MFG1	89.0	41.0	2.17	0.92	2.33	0.53	1.03	3281
EFG1	57.0	40.3	1.41	0.70	1.97	0.49	1.48	3145

Mean of measures unless otherwise noted; channel width (CW); wetted width (WW); S.D. of Depth (standard deviation of depth).

4.1 Stream Habitat Assessment

Stream habitat at Middle Fork Grand was comparable to the SHAPP control station on East Fork Grand River. All test station scores exceeded 75 percent of the SHAPP control score. MDNR (2003d) methods identified relatively high quality habitat, which implied that the impairment was not related to stream habitat. Stream habitat assessments were conducted in the fall, when all stations were fully supportive of the macroinvertebrate community. Although the stream habitat quality scores decreased by nearly 30 points from upstream (#4) to downstream (#1), the slight decline in habitat quality did not appear to affect the macroinvertebrate community.

Prevalent habitat features included sand substrate at all stations and narrow riparian corridors, especially in some downstream areas. The quantity of in-stream fine sediment or other local influences may have effects on macroinvertebrate communities (Zweig and Rabeni 2001).

4.2 Biological Assessment

The biological assessment consisted of macroinvertebrate community analyses and physicochemical water quality analyses. All stations were fully supportive of the macroinvertebrate community in the fall. One station (#2) was slightly impaired in the spring.

4.2.1 Station #2, Spring Macroinvertebrate Community Analyses

Macroinvertebrate community analyses consisted of comparisons between the SCIs and individual metric scores to BIOREF streams. Station #2 was considered partially supporting of the macroinvertebrate community in the spring.

The SCI scores and individual metric scores illustrated a difference between stations in the spring. Station #2 was considered to be partially supportive of the macroinvertebrate community in the spring. Lower than optimum TR, EPTT, and SDI metrics illustrated fewer taxa, fewer sensitive taxa, less diversity, and less even distribution at #2 than BIOREF streams. The BI at #2 was well within the optimum BIOREF scoring range, which illustrated that organic contamination was probably not the contributor of a slight impairment.

Station #2 was considered to be partially supportive of the biological category by only a slight margin. The TR, EPTT, and SDI each had SCI scores of three. Two of the metrics (EPTT and SDI) very nearly scored within the optimum range. The EPTT was one taxon below the optimum range and the SDI was 0.07 of a point below the optimum. Had either of these metrics reached the optimum BIOREF score, station #2 would be considered fully supportive of the biological community (non-impaired).

The DMFs indicated that Chironomidae greatly increased from fall (ca. 50 percent) to spring (ca. 85 percent) at all stations as a percentage of the total number of individuals. This may be a normal early season occurrence and not due to impairment. This increase may be directly related to the BI increase and the decreased SDI. Indirectly, the TR and EPTT could be less abundant as a result of the Chironomidae subsampled. The TR, EPTT, and SDI did decrease at all stations from the fall to the spring while the BI was slightly higher. Chironomid and other dominant taxa abundance apparently had an effect on the scores during both seasons, however, did not obviously illustrate the impairment at station #2.

Although station #1 was not considered impaired, the TR was considerably lower than upstream TR scores. This indicates that something caused the TR to decline much as was found in #2. The optimum BI did not illustrate an obvious influence of organic contaminants.

4.2.2 Station #2, Physicochemical Water Quality

Physicochemical water quality did not obviously identify the cause of impairment at station #2. However, water quality variables may have identified a source for low level organic input.

Several constituents of organic pollution were present in low concentrations during both sample seasons. Conductivity, TKN, total phosphorus, and chloride were elevated or detected in all stations. Elevated TKN (organic nitrogen) and chloride identified animal waste as a possible source. All other components were within normal ranges or not detected and no parameter exceeded WQS (MDNR 2005c).

Upstream and downstream bracketing of tributaries (Figure 2) did not identify a specific cause of impairment at station #2. Concentrations at stations #3 and #1 were similar to #2, so no local source was indicated. Overall, organic constituents were similar from upstream to downstream stations, with upstream being slightly higher. The presence of the indicators in all stations suggested that the source for the organic influence was upstream of all the stations and not delivered from the bracketed tributaries. The BI was also higher at the upper-most station #4 during both seasons, which supports that contention.

Concentrations of organic constituents were similar between seasons, which suggested that the organic input was continuous and probably not from non-point sources. Concentrations were only slightly elevated or detectable, which suggested that normal concentrations in the study area were minor during normal flow periods. Spring

discharge was approximately three-fold higher than fall, yet concentrations of constituents were similar to the fall. Organic constituents did not increase with increasing runoff during higher flow periods, which suggested that they might originate from controlled point source(s) upstream, although no permitted point source was identified upstream of the study area within Missouri. Animal related point sources in the Iowa portion of the Middle Fork Grand River watershed should be researched.

4.3 Channel Measurements

Channelized streams tend to be straighter, wider, and shallower with less variation of depth given similar flow conditions (MDNR 2005a). Channel measurements on East Fork Grand River were similar at all stations and did not identify what caused the impairment at station #2.

There are no readily available sources of information and few public records of non-navigable river channelization, however, drainage project information can sometimes be found at county courthouses. An example is information found at the Gentry County Circuit Clerk and Recorder's Office in Albany, Missouri. Local drainage district records are available in the form of engineering plans and drawings concerning the channelization of a large portion of the Middle Fork Grand River (Plan for Reclamation, Middle Fork Drainage District, Gentry County, Missouri, 1920, submitted by Clark E. Jacoby Engineering Company of Kansas City, Missouri). The planned channelization reach encompassed all MDNR sampling locations for this study.

Natural sinuosity has not returned to Middle Fork Grand River since it was channelized. The sinuosity ratio indicated that the stream was straighter than the control station at the East Fork Grand River. It appears that actual distance was nearly equal to the straight-line (aerial) distance. Furthermore, the control station was approximately 50 percent more sinuous than the test stations, suggesting that unmodified streams in the EDU are not straight. This is consistent with previous findings (AFS 1971; MDNR 2005a). Topographic (7.5 min) maps also show that the stream is very straight and relicts of the old channel are visible in several areas.

A potential result of channelization may be wider wetted stream distance during normal flow conditions (AFS 1971; MDNR 2005a). Wetted width in the test stream was not significantly different ($p=0.303$) from wetted width in the control stream (Appendix B).

Increased channel width has also been found to be an important result of channel modification (MDNR 2005a). Channel width was significantly greater than the wetted width in both the test ($p<0.001$) and the control ($p<0.005$) streams. This suggests that normal high flow channels are much wider than their normal wetted width. This may be a function of soil type and/or riparian management in northern Missouri. However, channel width in the test stream was significantly wider (<0.001) than the channel width in the control stream. Since watershed size appeared to be similar between test and control streams, widening may have been either intentional when the stream was straightened, or as a result of being straightened, due to increased water velocity potential.

Channelized streams may have less variation in depth and generally have more homogenous habitat, which may not support a high quality macroinvertebrate community (AFS 1971; MDNR 2005a). However, measurements show that Middle Fork Grand River is deeper with similar or greater variability of depth when compared to the control stream.

Overall, the Middle Fork Grand River was straighter and had a wider channel than the control, but it also had similar wetted width, similar or greater variability of depth, and was greater average depth. MDNR's (2005a) findings that channelized streams are shallower and wider with less variability of depth did not fit channel conditions found at the time of sampling. Given these results, only sinuosity and channel width indicated poor stream conditions.

Fish community evaluations help to identify the impact of channelization on aquatic communities of northern Missouri streams (Congdon 1971; Vokoun and Rabeni 2003; Williamson and Todd 2005). Fish community evaluations should be conducted on Middle Fork Grand River to further address the ability of channelized streams to support biological integrity.

5.0 Conclusion

The goal of this study was to determine if Middle Fork Grand River, Worth and Gentry Counties was impaired in the TMDL listed 303(d) study area. Station #2 was partially supporting of the macroinvertebrate community in the spring, by a slight margin. While organic (animal waste) constituents were present during both seasons in low concentrations, organic exposure was not an obvious influence that altered the community. The source of impairment at station #2 was not identified. Stream habitat was comparable to the SHAPP control.

The hypotheses were tested. The stream habitat quality at the test stations was comparable to the SHAPP control. The macroinvertebrate community was slightly impaired at station #2 and a slight seasonal difference was observed. Physicochemical water conditions and concentrations were consistent between stations and similarly found in low levels during both seasons. Channel measurements were not all similar to the control and indicated that the stream channel was altered.

6.0 Recommendations

1) Stream habitat should be maintained according to best management practices.

2) Identify sources for organic water chemistry parameters.

2) Periodically monitor the water quality.

3) Use sinuosity of the channel as an indicator of channel modification.

4) Fish community evaluations should be conducted on Middle Fork Grand River to further evaluate biological integrity of channelized streams.

7.0 Literature Cited

American Fisheries Society (AFS). 1971. Stream channelization, a symposium. E. Schneberger and J. Funk Eds. North Central Division, American Fisheries Society, Special Publication No. 2. 33rd Midwest Fish and Wildlife Conference. Omaha, Nebraska. 83 pp.

Congdon, J.C. 1971. Fish populations of channelized and unchannelized sections of the Chariton River, Missouri. *In*: Stream Channelization: A Symposium. Edward Schneberger and John L. Funk, Editors. North Central Division, American Fisheries Society, Special Publication No. 2. pp. 52-62.

Funk, J.L. 1968. Missouri's fishing streams. Missouri Department of Conservation, Division of Fisheries. D-J Series No. 5, February. 108 pp.

Missouri Department of Natural Resources. 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

Missouri Department of Natural Resources. 2003a. Flow measurements in open channels. Water Quality Monitoring Section-113. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 9 pp.

Missouri Department of Natural Resources. 2003b. Required/recommended containers, volumes, preservatives, holding times, and special sampling considerations. Field Services Section-001. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 25 pp.

Missouri Department of Natural Resources. 2003c. Semi-quantitative macroinvertebrate stream bioassessment project procedure. Field Services Section-030. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 24 pp.

Missouri Department of Natural Resources. 2003d. Stream habitat assessment project procedure. Field Services Section-032. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.

Missouri Department of Natural Resources. 2005a. Channel modification analyses of streams listed on the 303(d) list for sediment from non-point source agriculture 2002-2004. Water Quality Monitoring Section, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 7 pp. + Appendices

Missouri Department of Natural Resources. 2005b. Taxonomic levels for macroinvertebrate identifications. Water Quality Monitoring Section-209. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 30 pp.

Missouri Department of Natural Resources. 2005c. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 10-136.

Rabeni, C.F., R.J. Sarver, N. Wang, G.S. Wallace, M. Weiland, and J.T. Peterson. 1997. Biological criteria for streams of Missouri. Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri-Columbia, Columbia, Missouri. 261 pp.

Vokoun, J.C. and C.F. Rabeni. 2003. Recovery of prairie fish assemblages at the transition from channelized to nonchannelized: Implications for conservation of natural channels. Natural Areas Journal, 23:349-355.

Williamson, C. and B. Todd. 2005. Wyaconda river watershed inventory and assessment. Missouri Department of Conservation, P.O. Box 180, Jefferson City, Missouri.

Zweig, L.D. and C.F. Rabeni. 2001. Biomonitoring for deposited sediment using benthic invertebrates: A test on four Missouri streams. Journal of the North American Benthological Society 20 (4): 643-657.

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Appendix A

Middle Fork Grand River Macroinvertebrate Bench Sheets
Fall 2004 and Spring 2005

(NF=non-flow, RM=rootmat, SG=snag habitats; -99=present)

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0418721], Station #4, Sample Date: 9/15/2004 11:15:00 AM

ORDER: TAXA	**NF**	**RM**	**SG**
"HYDRACARINA"			
Acarina		1	
AMPHIPODA			
Hyalella azteca	1	79	61
COLEOPTERA			
Berosus		1	
Dubiraphia	3	3	
Helichus lithophilus		6	
Hydroporus	1		
Scirtes		1	
DIPTERA			
Ablabesmyia	6	2	12
Anopheles		6	
Ceratopogoninae	4	9	6
Chironomus	6		
Chrysops		1	
Cladotanytarsus	42		4
Cricotopus bicinctus	1	1	1
Cricotopus/Orthocladius			4
Cryptochironomus	12		
Cryptotendipes	14		
Dicrotendipes	16		34
Ephydridae		2	
Forcipomyiinae			1
Labrundinia	2	6	11
Mesosmittia		1	
Nanocladius			3
Ormosia	2		
Paracladopelma	7		
Paratanytarsus	9	10	9
Polypedilum convictum grp			1
Polypedilum halterale grp	8		
Polypedilum illinoense grp	4	32	1
Polypedilum scalaenum grp	7		
Procladius	1		1
Rheotanytarsus	6	12	8
Stempellinella	1		2
Stenochironomus			2
Tanytarsus	44	7	95
Thienemannimyia grp.		9	10
Tipula		1	
undescribed Empididae		3	

ORDER: TAXA	NF	RM	SG
EPHEMEROPTERA			
Caenis hilaris	2		2
Caenis latipennis	115	50	96
Callibaetis		4	
Hexagenia limbata	3		
Leptophlebiidae		4	
Paracloeodes	1	3	14
Procloeon	10	1	1
Stenacron		1	
Stenonema femoratum	1		
Tricorythodes	1		
HEMIPTERA			
Belostoma		-99	
Microvelia		1	
Neoplea		3	
Rheumatobates		1	
Trepobates		3	
LIMNOPHILA			
Physella		5	
ODONATA			
Argia		6	
Enallagma		23	1
Gomphus	3		
Progomphus obscurus	-99		
TRICHOPTERA			
Hydroptila			3
Nectopsyche	6	30	1
Oecetis		1	
Triaenodes		4	
TUBIFICIDA			
Limnodrilus hoffmeisteri			1
Tubificidae	1	5	1
VENEROIDEA			
Sphaeriidae	-99	9	

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0418720], Station #3, Sample Date: 9/15/2004 9:00:00 AM

ORDER: TAXA	**NF**	**RM**	**SG**
"HYDRACARINA"			
Acarina			1
AMPHIPODA			
Hyalella azteca		67	8
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	
COLEOPTERA			
Berosus			1
Dubiraphia	2	1	1
Helichus lithophilus		4	8
Hydroporus			1
Paracymus			1
Stenelmis		-99	
DIPTERA			
Ablabesmyia	3	2	9
Ceratopogoninae	3	1	
Chironomus	12		1
Cladotanytarsus	37		4
Corynoneura			1
Cricotopus bicinctus			1
Cryptochironomus	3		1
Cryptotendipes	38		
Dicrotendipes	19	9	26
Ephydridae	1		
Forcipomyiinae			1
Glyptotendipes		4	2
Harnischia	1	1	
Labrundinia		15	12
Nanocladius	5	7	
Ormosia	5		
Parachironomus		4	
Paracladopelma	2		
Paralauterborniella	2		
Paratanytarsus	5	10	9
Paratendipes			1
Phaenopsectra			4
Polypedilum		1	
Polypedilum convictum grp			3
Polypedilum fallax grp			2
Polypedilum halterale grp	14		1
Polypedilum illinoense grp	8	11	40
Polypedilum scalaenum grp	3		21

ORDER: TAXA	NF	RM	SG
Procladius	5		
Rheotanytarsus		16	34
Simulium			1
Stempellinella	8		1
Stenochironomus			1
Tanypus	1		
Tanytarsus	47	34	95
Thienemanniella			2
Thienemannimyia grp.		24	17
Tipulidae		1	
Zavrelimyia			1
EPHEMEROPTERA			
Brachycercus	7		
Caenis hilaris			1
Caenis latipennis	65	52	39
Callibaetis		1	
Heptageniidae			2
Hexagenia	24		
Leptophlebiidae		1	
Paracloeodes	1	3	11
Procloeon	21		
Stenacron	2		6
Stenonema femoratum			1
Tricorythodes		4	6
HEMIPTERA			
Belostoma		-99	
Corixidae	1		
Mesovelia		1	
Rheumatobates		1	
Trepobates	1	1	
LIMNOPHILA			
Physella		1	
ODONATA			
Argia		6	3
Enallagma		6	
Gomphidae	1		
Gomphus		2	
TRICHOPTERA			
Cheumatopsyche		2	2
Hydroptila			2
Nectopsyche	1	78	3
Oecetis	1		
TUBIFICIDA			

ORDER: TAXA	NF	RM	SG
Tubificidae	1	2	
VENEROIDEA			
Sphaeriidae		1	

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0418719], Station #2, Sample Date: 9/14/2004 2:30:00 PM

ORDER: TAXA	**NF**	**RM**	**SG**
"HYDRACARINA"			
Acarina			1
AMPHIPODA			
Hyalella azteca	1	14	
COLEOPTERA			
Berosus		1	
Dubiraphia		4	
Helichus basalis		1	
Helichus lithophilus	4	11	
Scirtes			1
Stenelmis		1	
Uvarus	1		
DECAPODA			
Orconectes virilis		-99	
DIPTERA			
Ablabesmyia	13		1
Axarus	1		
Ceratopogoninae	1		
Chironomus	2		
Cladotanytarsus	23		3
Cricotopus bicinctus		1	1
Cricotopus/Orthocladius	1		5
Cryptochironomus	23		
Cryptotendipes	20		1
Dicrotendipes	10	1	33
Ephydridae	1		
Forcipomyiinae			8
Glyptotendipes		1	
Hemerodromia			3
Labrundinia	5	7	
Nanocladius		1	
Paracladopelma	5		
Paralauterborniella			1
Paratanytarsus	2	7	2
Paratendipes	4		
Polypedilum convictum grp		4	15
Polypedilum halterale grp	2		
Polypedilum illinoense grp	19	1	13
Polypedilum scalaenum grp	2		3
Rheocricotopus		2	
Rheotanytarsus	14	63	25
Saetheria	2		

ORDER: TAXA	NF	RM	SG
Simulium	1	2	
Stempellinella	5		
Stenochironomus			3
Tanytarsus	47	21	92
Thienemanniella	2		6
Thienemannimyia grp.	1	12	3
EPHEMEROPTERA			
Acerpenna		5	
Baetis		7	5
Brachycercus	11		
Caenis hilaris	5	18	
Caenis latipennis	38	90	3
Heptageniidae		1	
Isonychia		1	
Leptophlebiidae	1		
Paracloeodes	6		4
Procloeon	22	2	1
Pseudocloeon		15	
Stenacron	3	7	
Stenonema femoratum	2		
Tricorythodes	1	25	1
HEMIPTERA			
Rhagovelia			1
LIMNOPHILA			
Physella		2	
MEGALOPTERA			
Sialis		-99	
ODONATA			
Argia		18	
Calopteryx		2	
Enallagma	2	2	
Gomphidae	3		
Gomphus	-99	1	
Libellula		-99	
Progomphus obscurus	2		
TRICHOPTERA			
Cheumatopsyche	3	53	10
Hydroptila			1
Nectopsyche	4	91	1
TRICLADIDA			
Planariidae		1	
TUBIFICIDA			
Enchytraeidae			1

ORDER: TAXA	NF	RM	SG
Tubificidae	1		
VENEROIDEA			
Sphaeriidae	1	5	

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0418718], Station #1, Sample Date: 9/14/2004 12:30:00 PM

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina			6
AMPHIPODA			
Hyalella azteca	1	56	1
COLEOPTERA			
Berosus	1	1	
Dubiraphia	1		
Helichus		1	
Hydroporus		5	
DECAPODA			
Orconectes virilis		-99	
DIPTERA			
Ablabesmyia	4	2	
Anopheles	1	1	
Ceratopogoninae	2	5	
Chaoborus	-99		
Chironomus	7		
Cladotanytarsus	19		2
Cricotopus bicinctus			2
Cricotopus/Orthocladius	2		26
Cryptochironomus	7		
Cryptotendipes	21		
Dicrotendipes	7	2	56
Ephydridae	1		
Forcipomyiinae			6
Glyptotendipes		1	
Hemerodromia		1	3
Labrundinia	4	7	1
Nanocladius	2		
Paracladopelma	2		
Paralauterborniella	2		
Paratanytarsus	1	4	4
Paratendipes	1		
Polypedilum convictum grp	3		19
Polypedilum halterale grp	4		
Polypedilum illinoense grp	19	9	14
Polypedilum scalaenum grp		1	1
Procladius	2		6
Rheotanytarsus	5	38	63
Simulium		1	1
Stempellinella	18		
Stenochironomus	1		8

ORDER: TAXA	NF	RM	SG
Tanytarsus	60	23	84
Thienemanniella			6
Thienemannimyia grp.		11	12
EPHEMEROPTERA			
Baetis			5
Brachycercus	8		
Caenis hilaris	3	7	3
Caenis latipennis	63	65	4
Cercobrachys			1
Fallceon			2
Hexagenia	14		
Isonychia			2
Leptophlebiidae		3	
Paracloeodes	8	9	4
Procloeon	17	2	1
Pseudocloeon			2
Stenacron		1	
Stenonema		1	2
Tricorythodes	4	7	
HEMIPTERA			
Corixidae		1	
Neoplea			1
Trepobates	1		
LIMNOPHILA			
Physella		4	
ODONATA			
Argia	1	5	
Enallagma		7	
Gomphus	6		
Libellulidae	1		
Macromia	1		
Progomphus obscurus	-99		
TRICHOPTERA			
Cheumatopsyche		3	16
Cyrnellus fraternus		1	
Nectopsyche	17	52	
TUBIFICIDA			
Tubificidae	3	3	
VENEROIDEA			
Sphaeriidae	-99	8	

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0503013], Station #4, Sample Date: 3/23/2005 3:30:00 PM

ORDER: TAXA	**NF**	**RM**	**SG**
AMPHIPODA			
Hyalella azteca	4	16	4
COLEOPTERA			
Dineutus		-99	
Dubiraphia	1		
Dytiscidae	1		
Hydroporus	4	1	2
DIPTERA			
Ablabesmyia	11	1	1
Ceratopogoninae	18		
Chironomus	4	1	
Cladotanytarsus	5	1	1
Corynoneura	3	2	
Cricotopus bicinctus	2	10	11
Cricotopus/Orthocladius	23	104	114
Cryptochironomus	10		2
Cryptotendipes	1		
Dicrotendipes	10		11
Diptera	1		
Glyptotendipes			1
Hemerodromia	1		
Hydrobaenus	60	3	16
Labrundinia		2	
Nanocladius	2	12	
Ormosia			1
Paracladopelma	2		
Paralauterborniella	2		
Parametriocnemus	1		
Paraphaenocladius		2	
Paratanytarsus	15	57	45
Pericoma		1	
Phaenopsectra	2		3
Polypedilum		1	
Polypedilum convictum grp	1	3	
Polypedilum halterale grp	8		
Polypedilum illinoense grp		1	
Polypedilum scalaenum grp	8		
Procladius	2		
Pseudosmittia	1		
Rheotanytarsus		3	10
Saetheria	8	1	
Stictochironomus	1		

ORDER: TAXA	NF	RM	SG
Tanytarsus	98	7	35
Thienemanniella	1	3	6
Thienemannimyia grp.	2	18	14
Zavrelimyia	2	9	
EPHEMEROPTERA			
Caenis latipennis	44	38	67
Hexagenia limbata	1		
Leptophlebia		1	
Stenacron		2	
HEMIPTERA			
Sigara	2		
ODONATA			
Argia		1	
Enallagma	4	5	
Progomphus obscurus	-99		
TRICHOPTERA			
Cheumatopsyche		1	3
Nectopsyche			1
Oecetis			1
TUBIFICIDA			
Tubificidae	2		
VENEROIDEA			
Sphaeriidae	1		

Aquid Invertebrate Database Bench Sheet Report

Middle Fk Grand R [0503012], Station #3, Sample Date: 3/23/2005 2:00:00 PM

ORDER: TAXA	**NF**	**RM**	**SG**
AMPHIPODA			
Crangonyx	-99		
Hyalella azteca	5	18	
COLEOPTERA			
Dineutus		-99	
Helichus lithophilus		1	
Hydroporus		1	
Peltodytes	1		
DIPTERA			
Ablabesmyia	2	3	
Axarus	1		
Ceratopogoninae	2		
Chironomus	4		
Cladotanytarsus	2		
Corynoneura	2	1	1
Cricotopus/Orthocladius	21	121	204
Cryptochironomus	5		
Cryptotendipes	2		
Dicrotendipes	7	4	
Diptera	1		
Endotribelos			1
Hydrobaenus	43	8	12
Labrundinia		3	
Larsia		3	1
Nanocladius		7	
Ormosia	1		
Paracladopelma	4		
Parametriocnemus		3	3
Paraphaenocladius	1		
Paratanytarsus	13	89	22
Phaenopsectra	1	1	5
Polypedilum fallax grp			1
Polypedilum halterale grp	1		
Polypedilum scalaenum grp	9	10	2
Rheotanytarsus	8	9	1
Saetheria			1
Simulium		1	9
Stictochironomus	1		
Tanytarsus	74	47	4
Thienemanniella		4	23
Thienemannimyia grp.	5	20	6
Tipula		-99	

ORDER: TAXA	NF	RM	SG
Zavrelimyia	4	4	
EPHEMEROPTERA			
Acerpenna		4	1
Caenis latipennis	42	31	
Heptagenia		1	
Hexagenia limbata	3		
Leptophlebia		1	
Stenacron	1		
Stenonema femoratum	1		
HEMIPTERA			
Ranatra fusca		-99	
Sigara	2		
ODONATA			
Argia		-99	
Enallagma		1	
Hetaerina		1	
TRICHOPTERA			
Cheumatopsyche	1	1	
Hydropsyche			1
Nectopsyche	2	1	
TUBIFICIDA			
Enchytraeidae	2		
Limnodrilus cervix	1		
Limnodrilus claparedianus	2		2
Limnodrilus hoffmeisteri	1		1
Tubificidae	9		

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0503011], Station #2, Sample Date: 3/23/2005 12:15:00 PM

ORDER: TAXA	**NF**	**RM**	**SG**
"HYDRACARINA"			
Acarina			1
AMPHIPODA			
Crangonyx		-99	
Hyalella azteca		13	
COLEOPTERA			
Berosus		-99	
Hydroporus		1	
DIPTERA			
Ablabesmyia	4	1	
Ceratopogoninae	1	3	1
Chironomus	16		
Cladotanytarsus	6		
Cricotopus bicinctus	10	37	4
Cricotopus/Orthocladius	24	79	241
Cryptochironomus	10		
Dicrotendipes		5	3
Hydrobaenus	45	2	
Nanocladius		4	
Ormosia		1	
Paracladopelma	8		
Paraphaenocladius		5	2
Paratanytarsus	10	46	
Paratendipes	4		
Phaenopsectra	1	1	
Polypedilum convictum grp		9	1
Polypedilum halterale grp	7		
Polypedilum illinoense grp		6	
Polypedilum scalaenum grp	2	1	
Rheotanytarsus	1	14	2
Simulium	1	2	40
Stictochironomus	7		
Tanytarsus	142	88	2
Thienemanniella	2	9	7
Thienemannimyia grp.	5	30	1
Zavrelimyia	2	2	
EPHEMEROPTERA			
Acerpenna	1	7	
Caenis latipennis	33	50	1
Hexagenia limbata	1		
Leptophlebia		-99	
Stenacron	1	2	

ORDER: TAXA	NF	RM	SG
Stenonema terminatum	1	1	
HEMIPTERA			
Sigara	6		
ODONATA			
Progomphus obscurus	1		
Somatochlora		-99	
TRICHOPTERA			
Cheumatopsyche	1	1	2
Nectopsyche		7	
TUBIFICIDA			
Enchytraeidae		1	
Limnodrilus hoffmeisteri		1	
Tubificidae	3	1	

Aquid Invertebrate Database Bench Sheet Report
Middle Fk Grand R [0503010], Station #1, Sample Date: 3/23/2005 10:45:00 AM

ORDER: TAXA	**NF**	**RM**	**SG**
AMPHIPODA			
Hyalella azteca		14	-99
COLEOPTERA			
Dineutus		1	
Hydroporus		1	
DIPTERA			
Ablabesmyia		1	
Ceratopogoninae	4		
Chironomus	3		
Cladotanytarsus	3	1	
Corynoneura	1	2	
Cricotopus bicinctus	6	79	49
Cricotopus/Orthocladius	25	31	146
Cryptochironomus	10		
Cryptotendipes	3		
Dicrotendipes	3	2	5
Harnischia	1		
Hydrobaenus	57	1	3
Labrundinia		1	1
Nanocladius		1	
Paracladopelma	7		
Paralauterborniella	1		
Paraphaenocladius	2	1	1
Paratanytarsus	8	25	6
Phaenopsectra	3		3
Polypedilum convictum grp		6	10
Polypedilum illinoense grp	1	8	
Polypedilum scalaenum grp	2		
Procladius	3		
Rheotanytarsus		18	8
Simulium	1		8
Stenochironomus			2
Tanytarsus	125	60	17
Thienemanniella	2	9	6
Thienemannimyia grp.		12	1
Tipula		-99	
Zavrelimyia	2	2	
EPHEMEROPTERA			
Acerpenna		1	
Caenis latipennis	17	8	
Heptagenia		2	-99
Hexagenia limbata	2		

ORDER: TAXA	NF	RM	SG
Leptophlebia		-99	
Stenacron	1	-99	
Stenonema femoratum		-99	
LIMNOPHILA			
Physella		1	
ODONATA			
Enallagma		1	
Ischnura		-99	
TRICHOPTERA			
Cheumatopsyche		4	
Nectopsyche		1	
Oecetis		1	
TUBIFICIDA			
Limnodrilus hoffmeisteri	1		
Tubificidae	1		

Appendix B

Channel Measurement Comparisons:
(SigmaStat, Version 2.0, 1997)

Mann-Whitney Rank Sum Tests (mw)
or
Studentized t-Test (ttest)

1) Wetted Width Control vs. Wetted Width Test Stream, $p=0.303$ mw
2) Channel Width Test Stream vs. Wetted Width Test Stream, $p<0.001$ttest
3) Channel Width Control vs. Wetted Width Control, $p=0.005$ mw
4) Channel Width Control vs. Channel Width Test Stream, $p<0.001$ mw

1) t-test Tuesday, January 17, 2006, 10:31:32

Data source: **Wetted Width Control (wwidthcont) v Wetted Width Test Stream (wwidthtest)**

Normality Test: Failed (P = 0.006)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Tuesday, January 17, 2006, 10:31:32

Group	N	Missing	Median	25%	75%
wwidthcont	10	0	37.000	32.000	47.000
wwidthtest	40	0	35.000	29.000	42.000

T = 298.000 n(small)= 10 n(big)= 40 (P = 0.303)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; **there is not a statistically significant difference (P = 0.303)**

2) <u>t-test</u> Tuesday, January 17, 2006, 10:08:27

Data source: **Channel Width Test Stream (chwidthtest) v Wetted Width Test Stream (wwidthtest)**

Normality Test: Passed (P = 0.129)

Equal Variance Test: Passed (P = 0.020)

Group Name	N	Missing	Mean	Std Dev	SEM
chwidthtest	40	0	75.400	14.827	2.344
wwidthtest	40	0	36.825	10.921	1.727

Difference 38.575 t = 13.248 with 78 degrees of freedom. (P = <0.001)

95 percent confidence interval for difference of means: 32.778 to 44.372

The difference in the mean values of the two groups is greater than would be expected by chance; **there <u>is</u> a statistically significant difference between the input groups (P = <0.001).**

Power of performed test with alpha = 0.050: 1.000

3) t-test   Tuesday, January 17, 2006, 10:06:52

Data source:**Channel Width Control (chwidthcont) v Wetted Width Control (wwidthcont)**

Normality Test: Failed (P = 0.002)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test   Tuesday, January 17, 2006, 10:06:52

Group	N	Missing	Median	25%	75%
chwidthcont	10	0	56.000	55.000	60.000
wwidthcont	10	0	37.000	32.000	47.000

T = 142.500 n(small)= 10 n(big)= 10 (P = 0.005)

The difference in the median values between the two groups is greater than would be expected by chance; **there is a statistically significant difference (P = 0.005)**

4) t-test Friday, January 13, 2006, 09:16:11

Data source: **Channel Width Control (chwidth) v Channel Width Test Stream (Chw test)**

Normality Test: Passed (P > 0.200)

Equal Variance Test: Failed (P = 0.002)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Friday, January 13, 2006, 09:16:11

Group	N	Missing	Median	25%	75%
chwidth	10	0	56.000	55.000	60.000
chw test	40	0	72.000	64.000	86.000

T = 86.000 n(small)= 10 n(big)= 40 (P = <0.001)

The difference in the median values between the two groups is greater than would be expected by chance; **there is a statistically significant difference (P = <0.001)**